and the fibre is the modal field of the LP_{01}-mode and its associated the first higher order, LP_{10}, mode and total chromatic disper-

Introduction: In addition to the effective cutoff wavelength of SINGLE-MODE FIBRES sizes from far fields of SIMPLE TECHNIQUE TO ESTIMATE SPOT SIZES FROM FAR FIELDS OF SINGLE-MODE FIBRES

Indexing terms: Optical fibres, Optical measurement

Accurate estimates of two characteristic spot sizes, \( W_p \) and \( W_{pp} \), based on measurements of far-field angles \( \theta_{3dB} \) and \( \theta_{40dB} \), made on two single-mode fibres of widely differing refractive index profiles (RIPs) are reported. The results including their near-field profiles are compared with those deduced from the measured RIPs of the fibres, and are found to be in good agreement and well within the measurement accuracy.

Experiment and data processing: Light from a HeNe laser (\( \lambda = 0.6328 \text{ m} \)) was launched into the test single-mode fibre (\(-1.5 \text{ m} \)) and, using phase-sensitive detection, the half-

Results and discussion: The results for spot sizes as calculated from the far-field angles \( \theta_{3dB} \) and \( \theta_{40dB} \) according to the formula as given in Reference 1 are tabulated in Table 1.

![Fig. 1](image-url)

The modal field profiles \( ^\wedge (R) \) of the LP_{01}-mode for these two fibres are obtained from numerical solution of the scalar wave equation (eqns. 4 in Reference 9), and are used to calculate the spot sizes \( W_{min} \) and \( W_p \) directly from eqns. 9 and 10 in Reference 1.

Table 1

<table>
<thead>
<tr>
<th>Fibre</th>
<th>Spot size from FF measurements</th>
<th>Spot size from RIP data</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>( W_p )</td>
<td>( W_{pp} )</td>
</tr>
<tr>
<td></td>
<td>( \text{mm} )</td>
<td>( \text{mm} )</td>
</tr>
<tr>
<td>Fibre 1</td>
<td>( 2.73 \pm 0.01 )</td>
<td>( 0.01 )</td>
</tr>
<tr>
<td>Fibre 2</td>
<td>( 3.07 \pm 0.04 )</td>
<td>( 0.06 )</td>
</tr>
</tbody>
</table>

Fibre 1 is from Yorkshire Technology (UK) and fibre 2 is from ITT (USA) along with the values for spot sizes deducible from RIPs of the two fibres. It can be seen that the values of \( W_{min} \) and \( W_p \) inferred from the two different measurement techniques are well within the theoretical error bounds reported in Reference 1. In Fig. 2 we have plotted the corresponding near fields. It can again be seen that the near fields derived from far-field measurements according to the method outlined above are in good agreement with near fields yielded by solution of the scalar wave equation on the basis of actual RIPs of the fibre.

In summary, we have provided a simple measurement technique to obtain a sufficiently accurate estimate of the two
characteristic spot sizes of the LP_{01}-mode as well as the mode field itself in a single-mode fibre.

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Fig. 2

- a Near-field profile (NFP) of fibre 1; solid curve corresponds to NFP deducible from fibre’s RIP and subsequent solution of eqn. 5, while broken curve represents NFP deducible from far-field measurements
- b NFP of fibre 2, with meaning of solid and broken curves as in (a)